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Characterization of MSW rejected fractions to fulfill RDF requirements and utilization

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ABSTRACT

In order to fulfil European and Portuguese legal requirements, adequate alternatives to traditional municipal waste landfilling must be found namely concerning organic wastes and others susceptible of valorisation. According to the Portuguese Standard NP 4486:2008, refuse derived fuels (RDF) classification is based on three main parameters: lower heating value (considered as an economic parameter), chlorine content (considered as a technical parameter) and mercury content (considered as an environmental parameter). The purpose of this study was to characterize the rejected streams resulting from the mechanical treatment of unsorted municipal solid waste, from the plastic municipal selective collection and from the composting process, in order to evaluate their potential as RDF. To accomplish this purpose six sampling campaigns were performed. Chemical characterization comprised the proximate analysis – moisture content, volatile matter, ashes and fixed carbon, as well as trace elements. Physical characterization was also done. To evaluate their potential as RDF, the following parameters established in the Portuguese standard were also evaluated: heating value and chlorine content. As expected, results show that the refused stream from mechanical treatment is rather different from the selective collection rejected stream and from the rejected from the compost screening in terms of moisture, energetic matter and ashes, as well as heating value and chlorine. Preliminary data allows us to conclude that studied materials have a very interesting potential to be used as RDF. In fact, the rejected from selective collection and the one from composting have a heating value not very different from coal. Therefore, an important key factor may be the blending of these materials with others of higher heating values, after pre-processing, in order to get fuel pellets with good consistency, storage and handling characteristics and, therefore, combustion behavior.

1. Introduction

Residual streams from municipal solid waste treatment plants are getting an increasing importance. In one hand, legal requirements have to be met, namely the reduction up to 35% of biodegradable municipal solid waste landfilling (regarding the production of 1995) but also the reduction of recyclable wastes and industrial non-hazardous wastes disposal in landfils. On the other hand, the energetic potential of these wastes is being widely studied as a way to promote waste valorisation and the use of endogenous energetic resources.

Waste management organizations are building infra-structures, such as biological-mechanical treatment operations to recover the biodegradable fraction of the municipal wastes. From these operations, fractions of unwanted wastes arise. In the same waste treatment plant, another rejected flow arises from the bio-wastes composting process, the compost rejected from the sieving operation done in order to separate physical contaminants. Otherwise, the selective collection of specific materials, like polymeric materials and their management, also lead to rejected fractions of wastes. These rejected fractions may also themselves be valued through the refuse derived fuels (RDF) production that may be used in specific industries.

The purpose of this study is to characterize the rejected streams resulting from the mechanical-biological treatment of municipal solid waste (MBTR) and from the packaging waste container selective collection (SCR) as well as the compost rejected (CR) in order to evaluate their valorisation as RDF, following the NP 4486:2008 specifications [1]. Physical characteristics, proximate analysis, heating value and chlorine content were evaluated in order to understand the energetic potential of the materials under study. Moreover to know the drawbacks expected and that are needed to overcome in the gasification or oxidation systems for energy recovery.

2. Experimental

The six collecting campaigns were performed in a MSW Treatment Plant in the spring of 2014 (one campaign), 2015 (two campaigns) and 2016 (three campaigns). The sampling methodology was performed according to EN 15442 and EN 15443 methods for sampling and for the laboratory sample preparation, respectively. Original sample portions of about 15 kg of MBTR and 10 kg of SCR rejected streams were used. For the CR analysis, 10 kg of samples were taken. Previously, the physical characterization of rejected streams was done, evaluating the content of the food wastes, green wastes, wood, paper/cardboard, plastics (several plastic polymers), textiles, glass, iron materials, aluminium, non magnetic metals, inerts, electric and electronics, and a final class of others (not classified above). After initial cutting, samples were prepared by cloning and quartering and afterwards hammer-milled and pressed. The proximate analysis was accomplished by the analysis of the moisture, volatile matter (VM), fixed carbon (FC) and ashes. An automatic bomb calorimetry was used to obtain the higher heating value (HHV). The lower heating value (LHV) was calculated in accordance to CEN / TS 15400, based on the theoretical elemental analysis of the different fractions, obtained from the physical characterization [2]. For the total chlorine content determination, a KOH absorption solution (0.2 M) was introduced in the calorimetric bomb and Mohr's method was used for quantification.

3. Results

As expected, the three streams have different compositions and are, as expected, characterized by their heterogeneity and variability. Figure 1 represents the main groups found in the waste streams from MBTR and SCR. While the MBTR stream has an important fraction of bio-wastes (food and green wastes), the SCR has mainly plastics and cardboard. Although the characterization was done with tighter classes (food and green wastes or different kinds of plastics), here broader classes are presented.

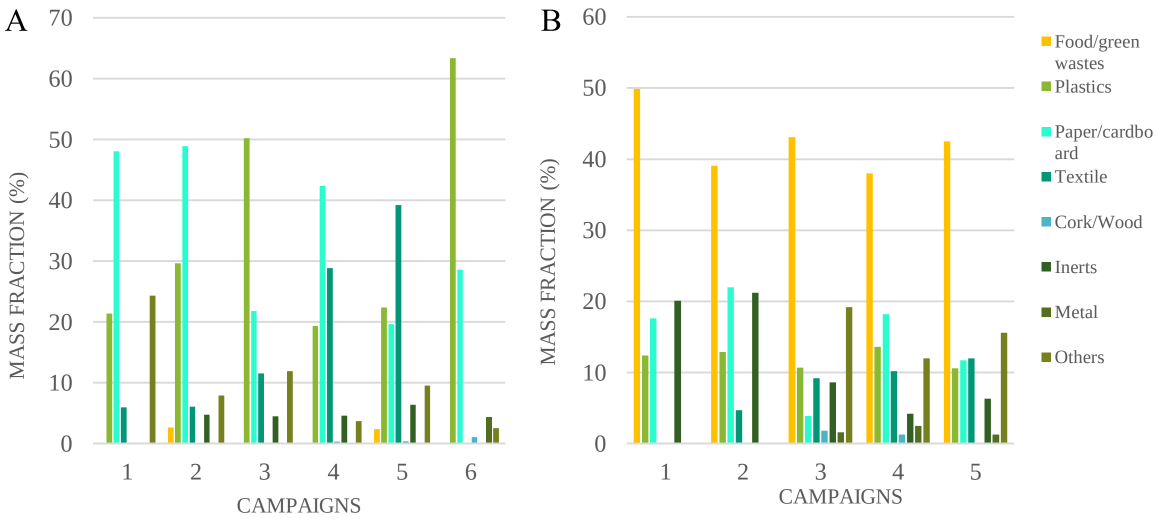

Fig.1 Physical characterization of the rejected streams: (A) packaging selective container (SCR); (B) mechanical-biological treatment (MBTR).

The rejected fraction from the composting process was also characterized. The main fraction of this stream is wood (58%) followed by plastics (22%), inerts (19%) and some metals (1%). The higher percentage of the wood is due to the fact that this material acts as a support agent in the composting process and is recovered, along with other fractions, after the compost refining. Although it has a high amount of easily burning material it has an important fraction of inerts (metals and glass).

The proximate analysis results show the variability between streams, calculated with the average of the campaigns (Figure 2). The MBTR has the highest moisture content, 53%, and the lowest volatile matter, 32%, while the SCR has the lowest moisture, around 20% in average and almost 70% of volatile matter. The rejected from the composting process has a moisture content around 29%, but a high volatile fraction.

According to Mokrzycki and Uliasz – Bochenczyk [3], RDFs with moisture content below 20%, are desirable in the cement industry, and can be valued as an alternative fuel. A high moisture content has a negative influence on the value of lower heating value (LHV) and consequently a reduction in the combustion efficiency as well as influence the emission of gases such as carbon monoxide, sulfur dioxide, nitrogen oxide and nitrogen dioxide. Nevertheless, in this industrial process, high incineration temperatures, the furnace area, the mean length of the oven and the alkaline environment within the furnace allow the use of this fuel very favorably both in environmental or economic perspectives. In order to use the rejected from MBTR and CR to produce RDF a drying system is necessary. The CR stream has a high volatile matter and low ashes content, which may indicate that this material has an interesting potential to energetic valorization.

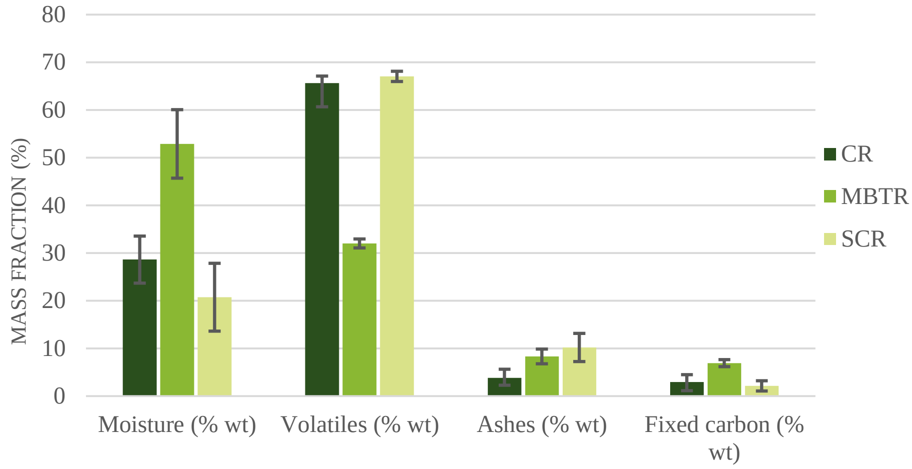

Figure 2. Proximate analysis of rejected streams

This physical characterization allows to predict the elemental composition, namely the hydrogen content for further LHV determination from the experimental higher heating value (HHV). The MBTR stream shows a biodegradable fraction (high percentage of food and green wastes), concentrating the carbon fraction and minimizing the CO_2 emissions, while in the SCR stream, carbon concentrates in the synthetic fraction, namely plastics, paper and cardboard. Therefore, concerning neutral carbon emission, MBTR material presents more favorable conditions for combustion although having higher moisture and chlorine contents (Figure 3) which may be problematic. The NP 4486:2008 considers in the worst class a chlorine concentration of 3% (dry basis) and some authors suggest as acceptable values for the cement industry less than 1.5% [4]. The chlorine concentrations obtained in the present work are below these values suggesting the absence of difficulties in cement kilns combustion and afterwards in produced cement quality.

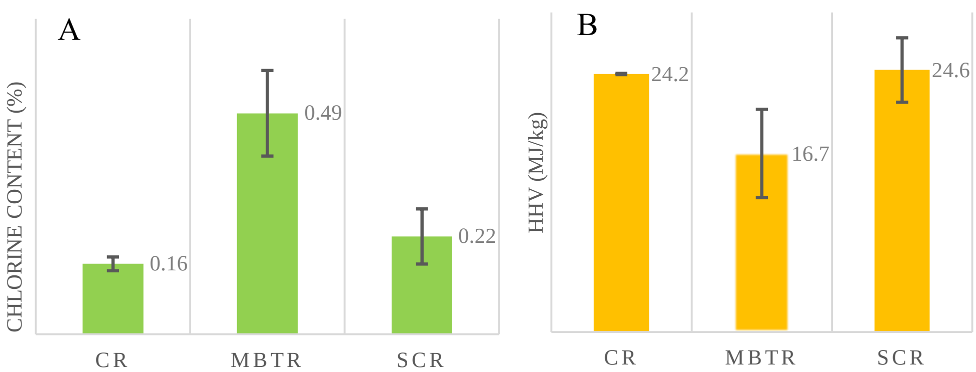

Figure 3. Chlorine content (A) and higher heating value (B) of streams from composting (CR), mechanical-biological treatment (BMTR) and the selective collection (SCR).

The SCR and CR wastes show higher HHV (Figure 3) comparing to MBTR wastes. The similar behavior of the first two streams is understandable since they have similar composition – the most representative fractions are paper, cardboard, plastics and wood in both rejected streams, in SCR about 70% and in CR 80%.

The NP 4486:2008 sets a classification system for the main RDF parameters, treated independently: lower heating value (as economic parameter), chlorine content (as technical parameter) and mercury content (as environmental parameter). The lower heating value characterization is represented in Figure 4. Stickling considering the average values, the SCR material classification is LHV 1 and Cl 2 whereas the MBTR material is LHV 2 and Cl 2 and CR is LHV 1 and Cl 1. Mercury content was not determined in the present work.

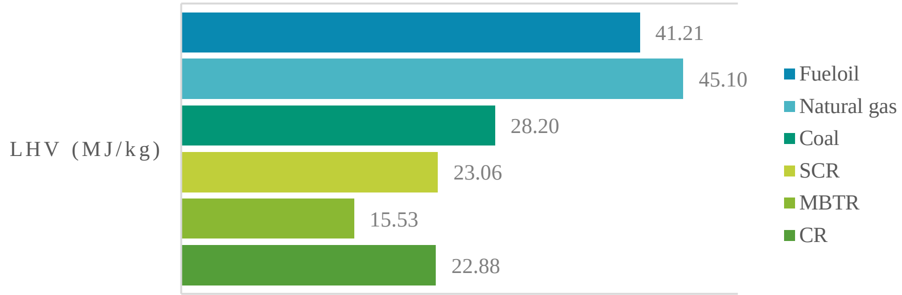

Figure 4. Lower heating value of the rejected streams and common fossil fuels.

According to the Portuguese legislation it is expected that RDF may be used in co-combustion or dedicated combustion systems. In fact, it is expected to perform mixtures of the management plants different rejected streams in order to produce a fuel with characteristics suitable for their intended purpose. The potential consumers of these fuels are concerned with economic, technical and environmental criteria. From Figure 4 it is possible to notice that the rejected from selective collection and from composting have an LHV not very different from coal [5]. Achieved results suggest that potential RDF prepared from MSW rejected fractions can be, in fact, an important resource advantageously replacing fossil fuels primary energy sources. Wastes fractions studied may provide, depending on market developments and on an economic and financial evaluation, a basis for RDF production with increased biogenic fraction incorporation. With these options, the Portuguese legislation suggested guidelines can be fulfilled to enhance the wastes valorization and the utilization of endogenous energetic resources as a way to minimize the amount of waste landfilled and also to accomplish the principles of self-supporting and proximity in the usage of energetic resources.

4. Conclusions

The waste materials under study present high heterogeneity. Obtained results show that the rejected materials heating value have a very interesting potential, namely if blended, to produce RDFs to use in specific industries, obtaining an end-product with suitable characteristics. However, further studies and important investments have to be made to achieve good quality RDFs.

5. Acknowlegment

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